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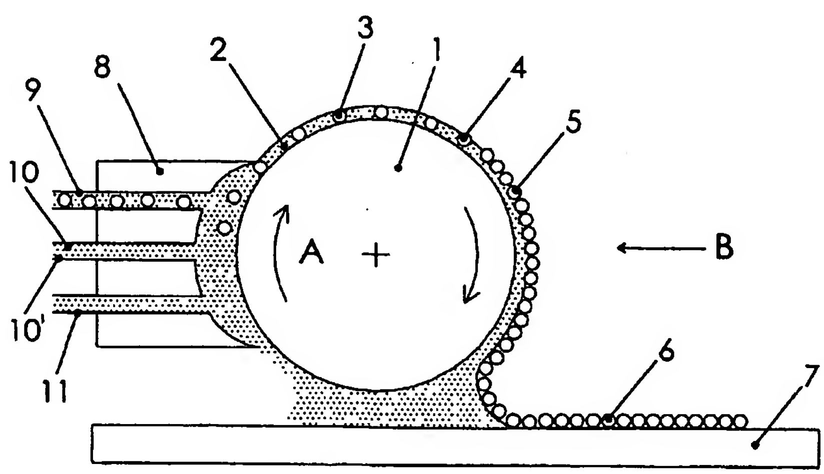
(54) Title: PROCESS FOR THE PREPARATION OF MONOLAYERS OF PARTICLES OR MOLECULES



(57) Abstract: A process is described to prepare monolayers of particles or molecules (3) comprising the steps of: injecting a liquid film (2) containing particles or molecules (3) dispersed therein on the external surface of a rotary member (1); adjusting the chemical characteristics of the particles or molecules (3), where such adjusting step carries the partides or molecules (3) to the surface of te thin liquid film (2); carrying the particles or molecules (3) absorbed at the gas-liquid interface of the thin liquid film (2) into a uniform monolayer (5); and transferring the monolayer (5) from the thin liquid film (2) surface to a solid substrate (7). Optionally, the step of working said uniform monolayer (5) is also present.

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PROCESS FOR THE PREPARATION OF MONOLAYERS OF PARTICLES OR MOLECULES

The present invention refers to a process for the preparation of monolayers of particles or molecules.

The fabrication of monolayers of insoluble particles to the gas-liquid interface was realized through uses of troughs usually full of aqueous solutions. To the gas-water interface, solutions containing amphiphilic molecules are usually spreaded, these being molecules made of a polar head and a chain of fatty acids. After the volatile solvent has evaporated, it leaves at the gas-liquid interface the amphiphilic molecules. Finally, a mobile barrier compresses the molecules in a monolayer. Therefore, essentially there occurs an immobile trough containing an unmoving subphase on which molecules are laterally transported through it by exploiting the surface tension difference between the subphase and the deposited solution, and a mobile barrier.

The transfer of the monolayer onto a solid substrate is realized through several processs. One is the so-called Langmuir-Blodgett process, and essentially comprises a vertical immersion of a solid plate in the subphase through the monolayer; by pulling up such plate, the layer is transferred onto the plate by lateral compression. That can be repeated many times. Another process, called the Langmuir-Schaeffer process, comprises the descent of an horizontal plate onto the monolayer. After a contact is made, the plate is again extracted with the monolayer on it. The prior most relevant document for the present invention is WO-A-98/53920, wherein a process is disclosed for the preparation of monolayers of particles or molecules in which one of the steps comprises the adjustment of the surface charge density of the particles or molecules in order to bring them to the surface of a thin liquid film.

By the way, in the device according to Fig.s 1 and 2 of document WO-A-98/53920 that enacts the related process described therein, it could be possible to have leakages of the liquid subphase between the injection block and the deposition substrate. Moreover, the subphase deriving from the

monolayer formation of the rotary element was also transferred in a different proportion according to the nature of liquids and solids. According to this prior patent, the pumping systems are external fittings that can only scavenge the liquid subphase excess. It was not possible in that case to further control the subphase itself. Another problem is given by the fact that, immediately after the injection of particles in the subphase coating the rotary element, the particles are adsorbed at the gas-liquid interface and are guided forward. The accumulation of the very first row of particles on an edge is the beginning of the monolayer preparation. However, the introduction of the transfer zone between the rotary element and the deposition surface creates a new problem, that is the beginning of the monolayer production. The distance between the rotating element and the deposition surface could be too wide to allow a controlled beginning of the monolayer preparation. Therefore, an edge is necessary to start producing the monolayer. In general, the problem with this type of prototype is that the monolayer transfer occurs without really having the chance of controlling or modifying the amount, the quality

and the effect of liquid under the monolayer during the transfer itself.

In the present document, the term "monolayer" designates a two-dimensional arrangement of particles. However, the monolayer could itself be chemically modified and coated, completely or partly, with another layer of material or molecules, that are organised on in bulk. The term "particles" refers to any type of colloids, molecules, virusses, cells, proteins, atoms, etc.

Object of the present invention is providing an improvement over the above-mentioned prior art document WO-A-98/53920, providing a process that allows using several sub-steps in order to take to the surface the affected particles or molecules. This is obtained by adjusting the chemical characteristics of such particles or molecules, through a chemical process that is adapted to the type of final application required.

A further object of the present invention is providing a process of the above type that succeeds in contolling the thin laminar flow subphase to the depositon devices. This control is useful in order to perform industrial applications.

Thanks to the present invention, it is possible to provide the basic principles for a Dynamic Thin Laminar Flow (DTLF) process in such a way as to extend the application to the preparation of amorphous or crystalline monolayers of all kind of particles and their following transfer on any type of liquid or solid substrate.

The above and other objects and advantages of the invention, which will appear from the following description, will be obtained with a process as claimed in Claim 1. Preferred embodiments and non-trivial modifications of the present invention are claimed in the dependent Claims.

The present invention will be better described by some preferred embodiments thereof, provided as a non-limiting example, with reference to the enclosed drawings, in which:

- Figure 1 is a side schematic view of a first embodiment of an apparatus to realise the prior art process, to which the present invention can also be applied;
- Figure 2 is a similar side view that shows a different working direction of the apparatus in Fig. 1.

In the course of the present description, the term "particle" means every type of molecules, polymers or aggregates whose mean diameter size is less than 100 microns. In particular, such term means all types of colloids, molecules, virusses, cells, proteins, atoms and the like.

The basic principles of the DTLF process are based on a combination of three different processes. The first one is that it is necessary to use a thin liquid film: its thinness must be in the order of micrometers. The second one is the adjustment of the chemical characteristics of the thin film particles in order to generate the adsorption of the particles at the gas-liquid interface without generating the adsorption among them at the gaseous interface or in the thin liquid film itself. Through document WO-A-98/53920, such process was realised by controlling the electric charges of the particles, while the present invention provides a more general process, that can be used also when it is not necessary to modify such electric charges. The process of the invention allows using an apparatus like the one disclosed in document WO-A-98/53920, that will be briefly described below, without making any substantial

modification thereto. The third part is such that, in order to create a force to guide the particles against an edge for the compression, the surface, on which the thin liquid film rests, is moved. This movement pushes the thin liquid film forward and creates, through the liquid viscosity, a surface force that finally pushes the particles forward.

As regards the second inventive process, the adjustment of the chemical characteristics of the particles or molecules implies the adsorption of the particles at the gas-liquid interface from the thin laminar flow on a rotary member 1. Such adsorption can be generated by any combination of:

- change of particles shape;
- change of components on particles surface;
- change of components of the solution among the particles;
- change of the physical or chemical status on the particles surface;
- change of the physical or chemical status of the solution among the particles; and
- magnetic, electric or vibration field.

The change of particles shape or surface or of the liquid can be generated by any combination of:

- reaction with a liquid in the sub-step;
- reaction with a gas around the rotary member 1;
- evaporation around the rotary member 1;
- temperature change;
- lighting to generate heating or a chemical reaction;
- magnetic, electric or vibration field.

The reactions with liquid or gas can be any combination of:

- catalysed reaction comprising enzymatic catalysis;
- reaction with the solvent comprising water;
- polymerisation;
- depolymerisation;
- oxidation;
- reduction;
- removal or addition of atoms or parts of molecules comprising hydration;
- exchange of ions, atoms or parts of molecules;
- change of the molecular shape.

The DTLF process requires the simultaneous existence of two characteristics: a liquid subphase around 1 to 10 micron thick and one mobile surface. This thinness is important for the DTLF process

because the particles in the thin liquid film will meet several times the gas-liquid interface during their transport due to the mobile solid surface. Another important aspect of the DTLF process is that the thinness of the film means having to deal with very small liquid volumes, in the microliter range. That means moreover that whichever modification of the physico-chemical features of the liquid film requires injecting or pumping outside small amounts of buffers or solutions. Moreover, the qualitative answer to any subphase modification is fast.

The second important feature is that the surface, on which the thin liquid film rests, is moving. This movement drives the solid-liquid interface and, because of the viscosity of the liquid, this movement is transmitted layer by layer up to the gas-liquid interface. These movements provoke the convection in the thin liquid film that transports particles towards the gas-liquid interface in an efficient way. Moreover, this transport is eased by the Brownian motions when the particles are at molecular level. Production efficiency can easily reach 100%.

These two features would be useless if further manipulations, necessary on the thin liquid film, were not taken into account. Such manipulations essentially comprise the adjustment of the surface charge densities for the particles, or in general the adjustment of the chemical characteristics of the particles themselves, in one of the above-mentioned ways.

Particle stability in the mass occurs because repulsion forces between particles are greater that attraction forces. For example, a high surface charge density means that the particles will remain in the mass, in solution or suspension. In this condition, no formation of monolayers is possible. The weakening of the surface charge density for particles will also weaken the repulsion force. It has been determined that the first phenomenon that takes place is the adsorption of particles at the gas-liquid interface. The final result, which is assembling the particles in a monolayer, is the same. Essentially, with the DTLF process the only two parameters to be controlled are the ionic forces in the subphase, for the particle A/W adsorption, and the surface forces that are pressing the particles onto the monolayer, the

surface force depending only on the cylinder rotation speed and the thin liquid film thickness. The further reduction of the repulsion forces provokes at the same time a second phenomenon that is the particle-particle adsorption at the gas-liquid interface. Therefore, aggregates are observed on the liquid surface, while in the mass particles remain balanced. Going on reducing the repulsion force between particles, particle to particle adsorption in the mass will be created. That will generate the precipitation of particles in the mass.

Clearly, the DTLF process works as soon as the particles in suspension or in solution are under unbalance conditions. In the majority of cases, this condition is present near the iso-electric point. A range of subphase conditions for every type of particles exist for an optimum adsorption at the gas-liquid interface. This optimum conditions can be found by injecting and pumping out liquids during the monolayer treatment, and following the monolayer production in real time.

The fact that the surface, on which the thin liquid film rests, is moving implies that as soon as the particles are absorbed, they are compressed

against the edge of the growing monolayer. Particles arrive one after the other. This sequence of arrival is very favorable for the formation of large bidimensional crystals with particles. Such crystals have been observed for protein and polystyrene particles. In principle, there are no limits for the size of particles and the nature of their material can be gold, silver, glass, etc.

With reference to Figs. 1 and 2, two preferred embodiments are shown of an apparatus to carry out the DTLF process according to the present invention. The inventive apparatus shown in Fig. 1 comprises a rotary member 1, in this case a clockwise-rotating cylinder, to which an injection module 8 is connected, this module 8 being equipped with three openings with respective inlet and outlet channels for the fluid: a channel 9 through which a thin liquid film 2 is injected, through adequate means (not shown), this film 2 containing a suspension of particles or proteins 3; a channel 10' through which, through adequate means (not shown), adsorption reagents 10 are injected to be put in contact with particles 3 in suspension in the thin liquid film 2; and a channel 11 connected to a suction pump (not shown) to suck the thin

liquid film 2 after the deposition of the monolayer 5.

The apparatus in Fig. 1 comprises moreover a substrate 7 on which the monolayer 5 is deposited. According to what is shown in Fig. 1, particles 3, after their surface charge density is modified by means of contact with reagents 10, are carried to the surface, that is at the gas-liquid interface, and are therefore adsorbed, as clearly appears from the particles designated by reference number 4. The rotation of the rotating member (arrow A) pushes particles 4 one against the other to form a continuous and uniform monolayer 5. By going on rotating member 1 and parallely by moving it in the lengthwise direction to a substrate 7 (in Fig. 1 in the direction of arrow B that is the opposite regarding the rotation sense for member 1), the monolayer 5 is deposited on the substrate 7 together with the thin liquid film 2, that is then sucked away by means of suction means 11. A monolayer of particles 6 will be obtained and therefore transferred onto the solid substrate 7, than in case of Fig. 1 is a hydrophobic substrate made with a slide of glass or metal.

The embodiment in Fig. 2 is the same as the one in Fig. 1 (and therefore the same parts are designated by the same reference numbers), apart from for the fact that the substrate 7 is made of hydrophylic material, that is composed of a clean glass plate or a mica sheet. Therefore, in this case, the deposition of monolayer 6 on it is carried out making the rotary member 1 advance in the direction of arrow C, that is the same as the rotation sense of the member.

The process of the present invention operates in a similarly effective way if the substrate 7 is composed of any type of liquid, on which it will therefore be possible to deposit one or more monolayers (through one or more successive application passes) of particles or molecules.

Some practical applications of the process and the apparatus according to the present invention provide that such adsorption reagents 10 are made of an acidic solution to a pH equal to approximately 4.0 for particles 2 of polystyrene or protein molecules. According to another example, the adsorption reagents 10 are composed of a solution made of 70% of acetonitrile for particles 2 of carbon 60 in a toluene film. According to a

further example, the adsorption reagents 10 can be a salts solution, in particular a cadmium sulfate solution for molecules 2 of proteins of the holoferritin type.

The invention can be practiced by realizing filters for ultrafiltration, whose pore diameter ranges from 1,000 to 1 nanometer.

The process according to the present invention can be therefore easily realised by the above-described apparatus, since such apparatus is structured in such a way as to be able to be applied both to the inventive process, and to the similar prior art processs.

The present invention further provides a process for the preparation of monolayers of particles or molecules comprising the steps of:

- injecting a thin liquid film containing such particles or molecules dispersed therein on the external surface of a rotary element (not shown);
- adjusting the chemical characteristics of particles or molecules, where the step of adjusting the chemical characteristics takes the particles or molecules to the surface of the thin liquid film;

transporting the particles or molecules being adsorbed at the gas-liquid interface of the thin liquid film into a uniform monolayer;

- working on the uniform monolayer; and
- transferring the worked monolayer from the thin liquid film surface onto a solid substrate.

In particular, the step of adjusting the chemical characteristics of particles or molecules consists in adjusting the surface charge density of the particles or molecules through the injection of adsorption reagents.

Moreover, the step of working on the uniform monolayer comprises the steps of:

- triggering the workings on the monolayer after its formation through the level variation of triggering means;
- controlling the triggering means volume in order to guarantee an efficient working according to the applications; and
- controlling the triggering means composition in order to perform a chemical working on the monolayer according to the applications.

The step of working on the uniform monolayer further comprises the step of performing a counterflow when working the monolayer.

In order to carry out the above-described process steps, it will be necessary to take into account the presence of a Transfer Zone between the thin laminar flow, where the monolayer is formed, and the deposition area, where the monolayer is transferred onto a solid support to be stored or further treated.

The Transfer Zone where the volume control is performed is realised by a vessel (not shown) full of a fluid. The monolayer or thin film coming from the thin laminar flow area is sent to the gas-fluid interface in the vessel and is guided forwards towards the other end of the vessel. A fraction of the thin laminar flow above the rotary element is guided into the vessel subphase. This will modify the subphase volume. This could modify the monolayer deposition characteristics. In order to control the deposition conditions with respect to the subphase level in the transfer zone, draining devices and/or injecting devices (not shown) can be used, as well as all other devices that can control the monolayer interface level in the subphase.

It can happen that the subphase composition in the vessel is different from the monolayer subphase below coming from the thin laminar flow area. The

volume and composition variation of the subphase into the vessel, separately or simultaneously could change the monolayer itself and its deposition characteristics. Therefore washing or reactive fluids can be inserted.

The process of the invention can be also used for well known applications in the art, wherein the monolayer deposition substrate is hydrophilic and the liquid film is further attached to the substrate; the process then further comprises the step of sucking the liquid film attached to the substrate away from the substrate itself. In such case, the substrate is composed of a clean glass plate or a mica sheet.

Moreover, the process of the invention can be applied to an hydrophobic substrate, and the liquid film is not attached to the substrate but remains on the external surface of the rotary element; the process then further comprises the step of sucking the liquid film attached to the substrate away from the substrate iself. In such case, the substrate is composed of a glass or metal plate.

When adsorption reagents are used, they are composed of an acidic solution at a pH equal to 4.0 for polystirene particles or protein molecules. In

particular, the adsorption reagents are composed of a 70% acetonitrile solution for carbon 60 particles in a toluene film.

As an alternative the adsorption reagents are a saline solution, in particular a cadmium sulphate solution for protein molecules of the holoferritin type.

The process of the invention is generally applied to a thin liquid film whose thickness is on the order of microns.

With the above-described process, it is possible to realise the following desired effects:

a) controlling the subphase amount to be left on the deposition surface;

b) avoiding leakages and other uncontrolled modifications of this type;

c) being able to partly or totally modifying the resulting subphase after the monolayer preparation above the thin laminar flow towards another subphase (gaseous, liquid or solid subphase) that could have on the monolayer the following effects:

- not having any residual after the subphase evaporation in or on the monolayer, and between the monolayer and the deposition surface;

- inducing reactions (biological, chemical, physical, electrical, mechanical and others) on the monolayers;
- inserting into the monolayers some additives for several purposes, such as softening or hardening, adsorption (glue or chemical or physical lubrication, etc.), absorption (chemical or physical absorption), surface reaction catalysis, electric effects (conduction, insulation, semiconduction, superconduction), magnetic effects (information storage, electromagnetic effects, opto-magnetic effects, magneto-optical effects, etc.), optical effects (phosphorescence, fluorescence, diffraction, absorption, diffusion, reflection, etc.), photochemical effects (photosynthesis, photochromatism, etc.);
- inserting between the monolayer and the solid substrate some additives for several purposes, such as softening or hardening, adsorption (glue or chemical or physical lubrication, etc.), absorption (chemical or physical absorption), surface reaction catalysis, electric effects (conduction, insulation, semiconduction, superconduction), magnetic effects (information storage, electromagnetic effects, opto-magnetic effects,

magneto-optical effects, etc.), optical effects (phosphorescence, fluorescence, diffraction, absorption, diffusion, reflection, etc.), photochemical effects (photosynthesis, photochromatism, etc.);

- inserting onto the monolayer some additives for several purposes, such as softening or hardening, adsorption (glue or chemical or physical lubrication, etc.), absorption (chemical or physical absorption), surface reaction catalysis, electric effects (conduction, insulation, semiconduction, superconduction), magnetic effects (information storage, electromagnetic effects, opto-magnetic effects, magneto-optical effects, etc.), optical effects (phosphorescence, fluorescence, diffraction, absorption, diffusion, reflection, etc.), photochemical effects (photosynthesis, photochromatism, etc.);

- modifying the deposition surface before, during or after the monolayer deposition for several purposes, such as softening or hardening, adsorption (glue or chemical or physical lubrication, etc.), absorption (chemical or physical absorption), surface reaction catalysis, electric effects (conduction, insulation,

semiconduction, superconduction), magnetic effects (information storage, electromagnetic effects, opto-magnetic effects, magneto-optical effects, etc.), optical effects (phosphorescence, fluorescence, diffraction, absorption, diffusion, reflection, etc.), photochemical effects (photosynthesis, photochromatism, etc.);

- producing a gaseous subphase under the monolayer with bubbles, a continuous gas layer or other gaseous volume forms. These gaseous volumes could be inserted or created in situ through some chemical or physical reactions or processes. These gaseous volumes could be attached to the deposition surface, under the monolayer surface, into the space between the mentioned surface, or in a combination of the three previously-mentioned positions;
- suspending the monolayer on a magnetic or electrostatic field in order to avoid any contact with solids or liquids. This is a way to perform reactions or exchanges with gases or magnetic or electric fields on both faces during the transfer towards the deposition area and forwards;
- being able to completely or partly modify the subphase of monolayer after having prepared the

monolayer above the thin laminar flow using the Transfer Zone between the rotary element and the deposition surface through any combination of operations such as heating, cooling, lighting, radiating, vibration or sound, turbulences, electric field or current, magnetic field or pulse and contact with a solid surface, always for the above-mentioned purposes.

Finally, the process of the present invention allows providing a new way to start the production of monolayers with the Transfer Zone between the rotary element and the deposition surface. At the beginning of the monolayer preparation, the accumulation of particles realising the very first row of the monolayer occurs if there are means (not shown) that are present in the particles path in order to block their movement. After having initialised the monolayer preparation, such means must not prevent the monolayer from reaching the deposition area.

Some preferred embodiments of the present invention have been previously shown and described: obviously, the skilled people in the art will immediately understand that numerous variations and modifications, that are functionally equivalent to

the previous ones, can be made without departing from the scope of the invention as pointed out in the enclosed Claims.

In particular, the inventive process, as already partly seen above, can be used in a very efficient and advantageous way at industrial level to realise a very wide range of interesting applications, among which the following can be cited as non-limiting examples:

- use of magnetic particles for magnetic data storage disks;
- ultrafiltration; and
- superconduction.

CLAIMS

1. Process for the preparation of monolayers of particles or molecules (3), said process comprising the steps of:
   - injecting a thin liquid film (2) containing said particles or molecules (3) dispersed therein on an external surface of a rotary member (1);
   - adjusting chemical characteristics of said particles or molecules (3), said step of adjusting chemical characteristics carrying said particles or molecules (3) at a surface of said thin liquid film (2);
   - carrying said particles or molecules (3) adsorbed at a gas-liquid interface of the thin liquid film (2) into a uniform monolayer (5);
   - transferring said monolayer (5) from the surface of said thin liquid film (2) to the solid substrate (7).
2. Process according to Claim 1, characterised in that the step of adjusting the chemical characteristics of said particles or molecules (3) implies the adsorption of the particles at

the gas-liquid interface from the thin laminar flow on a rotary member (1).

3. Process according to Claim 2, characterised in that said adsorption is generated by a change of the shape of the particles (3).
4. Process according to Claim 2, characterised in that said adsorption is generated by a change of components on the surface of the particles (3).
5. Process according to Claim 2, characterised in that said adsorption is generated by a change of components of the solution among the particles (3).
6. Process according to Claim 2, characterised in that said adsorption is generated bya change of the physical or chemical status on the surface of the particles (3).
7. Process according to Claim 2, characterised in that said adsorption is generated by a change of the physical or chemical status of the solution among the particles (3).
8. Process according to Claim 2, characterised in that said adsorption is generated by magnetic, electric or vibration field.
9. Process according to Claim 3, 4 or 6, characterised in that said change of the shape or

the surface of the particles (3) or of the liquid is generated by a reaction with the liquid in the sub-step.

10. Process according to Claim 3, 4 or 6, characterised in that said change of the shape or the surface of the particles (3) or of the liquid is generated by a reaction with a gas around a rotary member (1).

11. Process according to Claim 3, 4 or 6, characterised in that said change of the shape or the surface of the particles (3) or of the liquid is generated by an evaporation around a rotary member (1).

12. Process according to Claim 3, 4 or 6, characterised in that said change of the shape or the surface of the particles (3) or of the liquid is generated by a temperature change.

13. Process according to Claim 3, 4 or 6, characterised in that said change of the shape or the surface of the particles (3) or of the liquid is generated by a a lighting to generate heating or a chemical reaction.

14. Process according to Claim 3, 4 or 6, characterised in that said change of the shape or the surface of the particles (3) or of the liquid

is generated by a magnetic, electric or vibration field.

15. Process according to Claim 9 or 10, characterised in that said reactions with liquid or gas are composed of a catalysed reaction including the enzymatic catalysis.

16. Process according to Claim 9 or 10, characterised in that said reactions with liquid or gas are composed of a reaction with the solvent comprising water.

17. Process according to Claim 9 or 10, characterised in that said reactions with liquid or gas are composed of a polymerisation.

18. Process according to Claim 9 or 10, characterised in that said reactions with liquid or gas are composed of a depolymerisation.

19. Process according to Claim 9 or 10, characterised in that said reactions with liquid or gas are composed of an oxidation.

20. Process according to Claim 9 or 10, characterised in that said reactions with liquid or gas are composed of a reduction.

21. Process according to Claim 9 or 10, characterised in that said reactions with liquid

or gas are composed of a removal or addition of atoms or parts of molecules comprising hydration.

22. Process according to Claim 9 or 10, characterised in that said reactions with liquid or gas are composed of an exchange of ions, atoms or parts of molecules.

23. Process according to Claim 9 or 10, characterised in that said reactions with liquid or gas are composed of a change of the molecular shape.

24. Process according to Claim 1, characterised in that it further comprises the step of making said rotary member (1) move in a longitudinal direction with respect to said substrate (7), said monolayer (5) being separated from said thin liquid film (2) and being adsorbed on said substrate (7).

25. Process according to Claim 24, characterised in that said substrate (7) is hydrophilic, said liquid film (2) being also attached to said substrate (7), said longitudinal movement step of said rotary member (1) being carried out in the same direction as the rotation direction of said rotary member (1), said process further comprising the step of sucking said liquid film

(2) attached to said substrate (7) away from said substrate (7).

26. Process according to Claim 25, characterised in that said substrate (7) is composed of a clean glass plate or a mica sheet.

27. Process according to Claim 24, characterised in that said substrate (7) is hydrophobic, said liquid film (2) not being attached to said substrate (7) but remaining on the external surface of said rotary member (1), said longitudinal movement step of said rotary member (1) being carried out in the direction opposite to the rotation direction of said rotary member (1), said process further comprising the step of sucking said liquid film (2) away from said substrate(7).

28. Process according to Claim 27, characterised in that said substrate (7) is composed of a glass or metal plate.

29. Process according to any one of the previous Claims, characterised in that said adsorption reagents (10) are composed of an acid solution at a pH equal to 4.0 for particles (2) of polystyrene or protein molecules.

30. Process according to any one of the previous Claims, characterised in that said adsorption reagents (10) are composed of a 70% acetonitrile solution for particles (2) of carbon 60 in a toluene film.

31. Process according to any one of Claims 1 to 28, characterised in that said adsorption reagents (10) are a saline solution.

32. Process according to Claim 31, characterised in that said saline solution is a cadmium sulfate solution for molecules (2) of proteins of the holoferritin type.

33. Process according to any one of the previous Claims, characterised in that said thin liquid film (2) has a thickness of the order of microns.

34. Process according to Claim 1, characterised in that it further comprises, after said step of carrying said particles or molecules (3), the step of working on said uniform monolayer (5).

35. Process according to Claim 1, characterised in that said step of adjusting chemical characteristics of said particles or molecules consists in adjusting the surface charge density of said particles or molecules through the injection of adsorption reagents.

36. Process according to Claim 34 or 35, characterised in that said step of working on said uniform monolayer comprises the steps of:

- triggering said working on said monolayer after its formation through the level variation of triggering means;
- controlling a volume of said triggering means in order to guarantee an efficient working according to applications; and
- controlling a composition of said triggering means in order to perform a chemical working on said monolayer according to applications.

37. Process according to Claim 36, characterised in that said subphase of controlling a composition of said triggering means consists in controlling a subphase amount to be left on the deposition surface.

38. Process according to Claim 36, characterised in that said subphase of controlling a composition of said triggering means consists in completely or partly modifying the resulting subphase after having prepared the monolayer above the thin laminar flow towards another subphase (gaseous, liquid or solid subphase).

39. Process according to Claim 36, characterised in that said subphase of controlling a composition allows not having any residues after the subphase evaporation in or on the monolayer, and between the monolayer and the deposition surface.

40. Process according to Claim 36, characterised in that said subphase of controlling a composition allows inducing reactions of the biological, chemical, physical, electrical or mechanical type on the monolayers.

41. Process according to Claim 36, characterised in that said subphase of controlling a composition allows inserting some additives into the monolayer.

42. Process according to Claim 36, characterised in that said subphase of controlling a composition allows inserting some additives between the monolayer and the solid substrate.

43. Process according to Claim 36, characterised in that said subphase of controlling a composition allows introducing some additives onto the monolayer.

44. Process according to Claim 36, characterised in that said subphase of controlling a composition allows modifying the deposition surface before, during or after the monolayer deposition.

45. Process according to Claim 36, characterised in that said subphase of controlling a composition allows producing a gaseous subphase under the monolayer with bubbles, a continuous gas layer or other gaseous volume forms, said gaseous volumes being inserted or created in situ through chemical or physical reactions or processes.

46. Process according to Claim 36, characterised in that said subphase of controlling a composition allows producing a gaseous subphase under the monolayer with bubbles, a continuous gas layer or other gaseous volume forms, said gaseous volumes being attached to the deposition surface, into the space between said surfaces, or in a combination of the three previously-cited positions.

47. Process according to Claim 36, characterised in that said subphase of controlling a composition allows suspending the monolayer onto a magnetic or electrostatic field in order to avoid any contact with solids or liquids, thereby allowing to perform reactions or exchanges with gases or magnetic or electric fields on both faces during the transfer towards the deposition area and forwards.

48. Process according to Claim 36, characterised in that said subphase of controlling a composition

allows partly or totally modifying the subphase or monolayer after the monolayer preparation above the thin laminar flow using a Transfer Zone between the rotary element and the deposition surface through any combination of operations such as heating, cooling, lighting, radiating, vibration or sound, turbulences, electric field or current, magnetic field or pulse and contact with a solid surface.

49. Process according to any one of Claims 41 to 48, characterised in that said workings are performed for several purposes, such as softening or hardening, adsorption (glue or chemical or physical lubrication, etc.), absorption (chemical or physical absorption), surface reaction catalysis, electric effects (conduction, insulation, semiconduction, superconduction), magnetic effects (information storage, electromagnetic effects, opto-magnetic effects, magneto-optical effects, etc.), optical effects (phosphorescence, fluorescence, diffraction, absorption, diffusion, reflection, etc.), photochemical effects (photosynthesis, photochromatism, etc.).

50. Process according to Claim 36, characterised in that said step of working on said uniform monolayer

further comprises the step of performing a counterflow when working said monolayer.

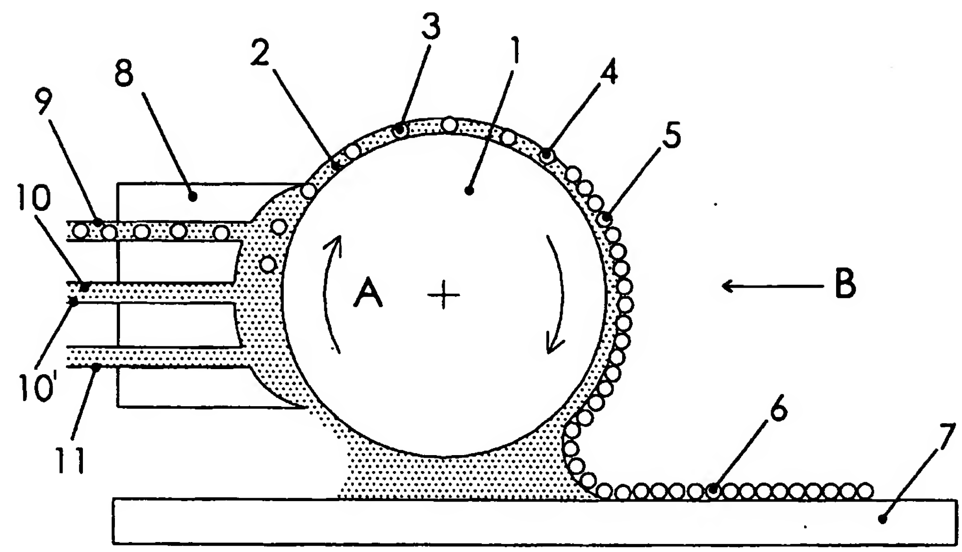

Fig. 1

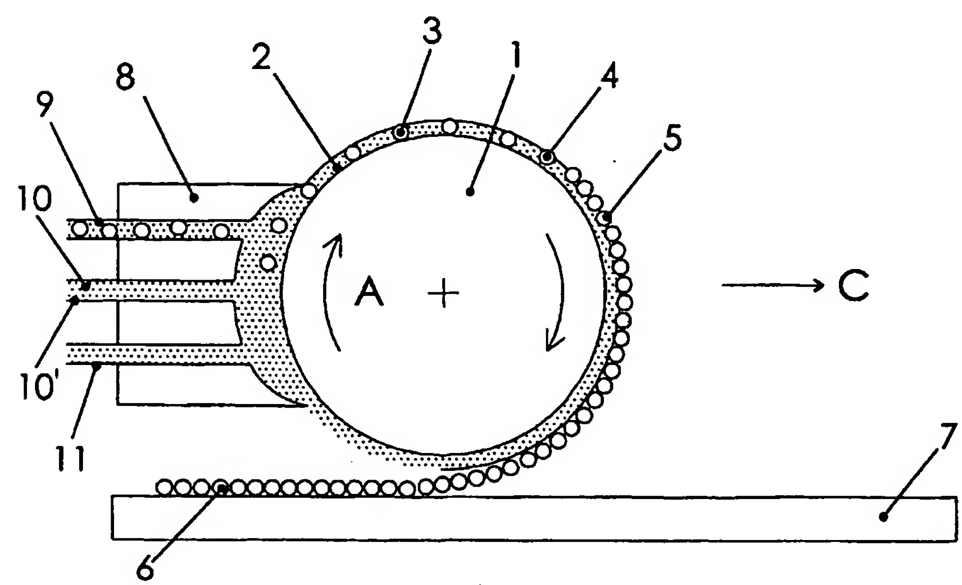

Fig. 2